Question 4 (25 marks)

a) Explain the main principle behind laser mapping systems. What is the basic sensor hardware for laser mapping systems?

b) An airplane carrying an airborne laser scanning (ALS) system emits a laser pulse with a pointing angle of $\alpha=5.000^{\circ}$ that takes 0.0051110 millisecond to reach an object on the ground and return to the sensor. At the same time, an onboard GPS-INS system measures the position of the laser coordinates as X=100.00m, Y=100.00m, Z=1000.00m, and the orientation as $\omega=\phi=\kappa=0$. What is the location of the object on the ground?

c) The rotation matrix R (ω,ϕ,κ) rotates the coordinate system of a tilted photograph to the coordinate system parallel to the reference ground system.

Determine the rotation angles (ω,ϕ,κ) if R has the following form:

$$R = \begin{pmatrix} 0.999910 & 0.013319 & 0.001635 \\ -0.013351 & 0.999671 & 0.021907 \\ -0.001343 & -0.021927 & 0.999759 \end{pmatrix}$$

(Formulas: $\sin\varphi = r13$, $\tan\kappa = -r12/r11$, $\tan\omega = -r23/r33$)

Question 5 (25 marks)

A project area is 16 km long in the east-west direction and 10.5 km wide in the north-south direction. It is to be covered with vertical aerial photography having scale of 1:12,000. A camera having a 152.4-mm-focal-length lens and a 230-mm square format is to be used. The nominal end lap and side lap are to be 60 and 30 percent, respectively. Beginning and ending flight lines are to be positioned along the boundaries of the study area. The only base map available for the area is at a scale of 1: 24,000. This map indicates that the average terrain elevation is 300 m above datum.

Compute the following data for the flight crew:

i. Flying height above mean sea level

ii. Ground coverage per image

iii. Distance between two successive axes of the strips.

iv. Number of flight lines required

v. Total number of photos needed

vi. Spacing of flight lines on the map

End of Examination

GROUP 3

What is Photogrammetry?

Photogrammetry is the science and technology of obtaining spatial measurements and other geometrically reliable derived products from photographs.

Explain the main differences between perspective and orthogonal projections.

Perspective projection is obtained by projecting an object to a projection plane with a bundle of rays from projection center located in finite distance from the projection plane, Angular relations between object features and image features are not the same.

Orthogonal projection is the parallel projection of an object to the chosen plane (map)

Name three (3) instruments used to measure image coordinates and briefly outline the measurement process involved.

i. Monocomparator- each photo is measured separately

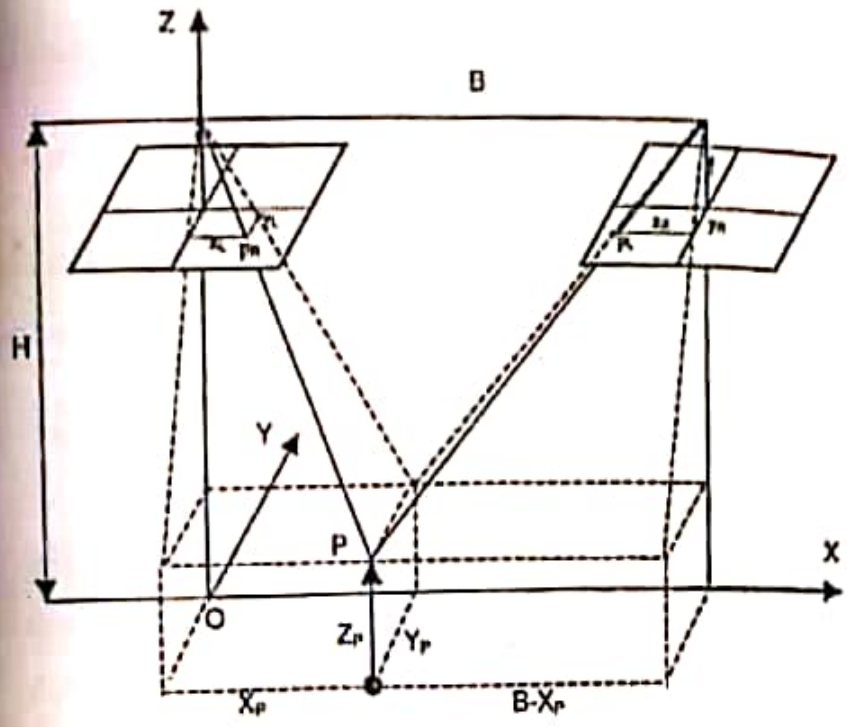
ii. Stereocomparator- simultaneous identification and measurement of image points on two photographs

iii. Analytical plotter- projective relations between each model point and corresponding image points are implemented analytically

GROUP 4

Explain the term depth of perception with respect to stereoscopic viewing.

Stereoscopic depth perception is a function of the parallactic angles. Parallactic angle is the angle of intersection of optical axes that converge on a certain point.



(14+6) marks

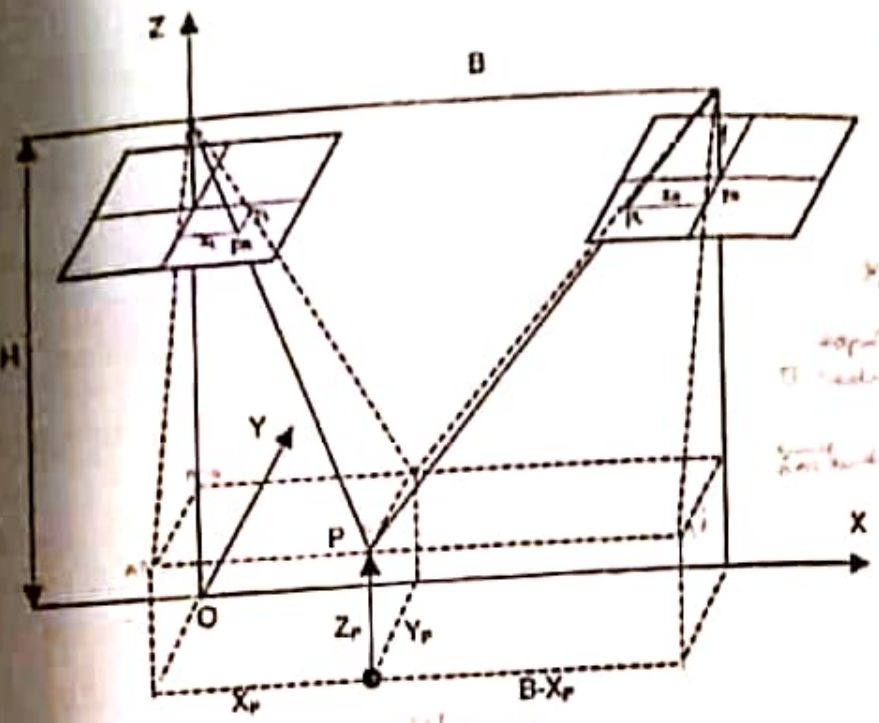
Question 6

The image coordinates of three points **A, B, C** and of the principal points **P** and **Q** on two overlapping vertical aerial photos were as follows

Point	Left photo		Right photo	
	x(mm)	y(mm)	x(mm)	y(mm)
P	0.0	0.0	-89.2	0.0
Q	+89.4	0.0	0.0	0.0
A	+12.8	+44.6	-76.6	+44.2
B	+16.4	+6.3	-72.8	+5.9
C	+20.2	-30.7	-69.6	-31.2

Given that the ground coordinates of A and C were 60,000mE, 72000mN and 61260mE, 71200m N respectively, estimate those of **B**.

(20) marks



a) Given that the elevation of point C is 200m above MSL and that the parallax reading for the same point is 11.89mm and that of point A is 10.96mm, the parallax constant is 80.71mm. Calculate the parallax difference between the two points and the elevation of point A if the flying height for a pair of photos is 1000m.

b) A mapping project is designed to use aerial photography at a scale of 1:10000 for a preliminary design of a development project covering an area of 20 x 15km. If a 15/23 camera is used with end and side overlaps of 60% and 30% respectively, calculate the following parameters if a flight plan along the longer side of the project boundary is to be prepared at a map scale of 1:20,000;

i. total number of flight lines

ii. total number of photographs to cover the project area

iii. total number of models

Atmospheric scattering occurs when the particals or gaseous molecules present in the atmosphere interact with the electromagnetic radiation and cause it to be redirected from its original path. Mention three types of scattering that take place and give one example for each.

(Rayleigh scattering- blue wavelengths scattered 5 times as often as red. Creates blue sky . Mie scattering smoke, dust, volcanic material and salt crystals scatter longer radiation wavelengths and Non-selective scattering- suspended aerosols (with diameters at least 10x larger than wavelengths) including all Mia particles and water droplets and ice crystals, scatter longer radiation wavelengths

State whether true or false:

Active Remote – detect only reflected sunlight or thermal IR and microwaves (False)

Passive Remote – beam own artificially produced energy to a target and record reflected component (False)

The entire range of EMR comprises the electromagnetic spectrum subdivided in divisions called wavelengths that share common characteristics. (False – Ans. Spectral Bands)

Three forms of energy transfer include: absorption, reflection and transmittance (False. Ans- conduction, convection and radiation)

The Sun is the minor **supplier of EM energy incident on the Earth – providing energy needed for terrestrial life and the natural processes operating in the atmosphere, water and upper layers of solid Earth.** (false)

EMR travels in a straight path at the speed of light – postulated by Albert Einstein in 1905 as ~ 300,000,000 km/sec (false. Ans. 300,000km/sec)

SECTION A

Question 1

a) Define briefly, the following photographic terms:

- F-number
- Nadir point
- Principle distance
- Flying height
- Fiducial marks
- Brightness factor

b) The image distance for a photograph of an object, which is located 4.5 meters from the camera, is 76.5mm. What image distance is required for perfect focus if the object is in infinity?

c) An aerial camera makes an exposure at a shutter speed of 1/1,000 sec. If the aircraft speed is 500 miles per hour, how far will the aircraft travel during the exposure?

(12+4+4) marks

Question 2

a. Name the instrument usually employed to measure the position of a point in a photograph.

b. Define the x- and y-parallaxes.

c. What are the systematic errors contained in the measured photo-coordinates that disturb the ideal linear relation between the perspective center, the image point and the ground point?

(2+4+14) marks

Question 3

a) What is meant by a vertical photograph?

b) What are the effects of tilt and relief displacement on a photo?

c) A vertical photograph captured at a flight height of 2000' above sea level shows a radio tower with a base elevation 540' above the same datum. The image of the tower has a relief displacement of 1.33". The distance from the photograph' s principal point to the top of the tower is 5.97". What is the height of the tower?

(4+8+8) marks

Question 4

a) Describe the meaning of photosensitivity and spectral sensitivity of photographic material.

b) What are the relationships between?

- F-number and shutter speed
- Film speed and emulsion grain size
- Resolution and emulsion grain size

c) Mention and explain one of the methods of camera calibration.

(4+6+10) marks

SECTION B

Question 5

The figure below shows an overlapping pair of truly vertical aerial photographs taken at equal flying height H above mean sea level (MSL) and having equal focal lenths f. The corresponding images of the ground point P are P_L on the left photo and P_R on the right photograph, respectively. The ground coordinate system XYZ has its origin at the MSL level location O of the left photo camera exposure station, i.e. the **X** and **Y** axes are parallel to the x and y axes of the photo system.

a) Derive the basic parallax equations for the ground coordinates of point P based on the illustrated geometry of the overlapping truly vertical photos.

b) Compute the ground coordinates $\mathbf{X_p Y_p Z_p}$ of point **P** using the previously derived parallax equations for the photo stereo pair, whose
focal length **f**=152mm, the air base **B**=1815m and the flying height **H**=3000m;
and the photo-coordinates of point **P** are:
for the left photo: x_L = +80.00mm y_L = -50.00mm, and
for the right photo: x_R = -20.00mm, y_R = -50.00

SECTION A

Question 1 (25 marks)

a) A vertical aerial photograph was taken with a 152.4-mm-focal-length camera from a flying height of 1385 m above datum. Images *a* and *b* of two ground points A and B appear on the photograph, and their measured photo coordinates are x_a = -52.35 mm, y_a = 48.27 mm, x_b = 40.64 mm and y_b = 43.88 mm. Determine the horizontal length of line AB if elevations of points A and B are 204 and 148 m above datum, respectively.

b) A distance *ab* on a vertical photograph is 65.0 mm, and the corresponding ground distance *AB* is 1150 m. If the camera focal length is 152.4 mm, what is the flying height above the terrain upon which line *AB* is located?

Assume that the values given for focal length, photo distance and ground length contain random errors of ± 0.005 mm, ±0.50 mm, and ±0.30 m respectively. What is the expected error in the computed flying height?

Question 2 (25 marks)

a) Discuss and give examples of the terms:

i) Active Remote and
ii) Passive Remote sensor systems

b) Mention three (3) most common bands of the electromagnetic spectrum used for remote sensing.

c) When electromagnetic radiation strikes matter, it interacts with it in possibly four main ways; Name the four (4) processes involved?

d) Three main types of scattering important to remote sensing are: Explain their effects.
- Rayleigh scattering
- Mia scattering
- Nonselective scattering

Question 3 (25 marks)

a) Spatial and non-spatial data are the two types of data to be entered in a GIS. Give a brief description of Spatial and non-spatial data?

b) Briefly describe what the terms digitizing and scanning mean in GIS data entry?

c) What are the two main types of data formats used in GIS?

d) Give three (3) advantages and disadvantages of Vector Data?

e) What does the term "Georeferencing" mean?

2. a) Describe two different conditions that are commonly enforced in analytical photogrammetry.

b) Distinguish between **Space Resection by** collinearity and **Space Intersection by** collinearity.

c) Aerial photography is to be taken from a flying height of 1830 m above average ground with a camera having a 152.4-mm focal length and a 23cm format. End lap will be 60 percent, and side lap will be 30 percent. What is the ground area covered by a single photograph and by the stereoscopic neat model?

(6+8+11 marks)

3. a) Mention Three (3) basic sensor hardware for laser mapping systems.

b) A laser mounted on an airplane emits a pulse that reflects off a target and returns to the sensor in 0.0066000 millisecond. Assume that the pulse is aimed directly down to the datum surface, that the speed of light is 299,792,458 m/s, and that the laser is at exactly 1 km above the datum. What is the object's height above datum?

c) Evaluate the contrasts between airborne laser scanning and (stereo-) photogrammetry from an application perspective.

(6+7+12 marks)

SECTION B

4. a) Briefly, explain what is meant by aerial triangulation.

b) Outline at least three (3) advantages of control extension by aerial triangulation

c) Mention at least five (5) sources of errors that are normally taken into account in aerial triangulation

d) Why is the similarity (conformal) transformation used in the Block adjustment by independent models?

(6+9+5+5 marks)

5. a) The relationship of between density and exposure of a photographic emulsion can be described by the characteristic curve called *D-log(H)* curve. With the help of a sketch diagram, explain the main components of the curve.

b) State the difference between contact printing and projection printing

c) Explain the five steps involved in processing black and white emulsion.

(10+6+9 marks)

STOP: GO BACK AND CHECK YOUR WORK!

The University of Zambia

School of Engineering

Department of Geomatic Engineering

2018/2019 Academic Year

Second-Half Year Final Examinations

GEE 3622: Principles of Data Acquisition and Processing

Time: Three (3) Hours

Instructions

1. This Examination is **Closed Book**
2. Calculators are permitted
3. Time allowed is **Three (3) Hours**
4. **Answer ALL QUESTIONS FROM SECTION (A) AND ONE FROM SECTION (B)**
5. Show all the work leading to the solution
6. Total marks for this Examination paper is 100

Please! Do Not Turn This Page Until Instructed By The Invigilator

Section B

Question Four

a) White light is made up of all the components of colour.

(i) Within what wavelength range does a human eye detect colour and what is this range called?

(ii) List and explain the three (3) visual variables of colour.

(iii) Draw and explain the additive colour mixture on a colour model used for computer display.

b) The role of a picture in computer graphics is described as:

(i) An end in itself and

(ii) A means to an end

Explain these two (2) concepts clearly giving appropriate examples.

c) Map projections are used to transform the curved surface of the Earth onto a flat plane of the map.

(i) Give and fully explain one (1) characteristic of map projections.

(ii) Give and fully explain one (1) property of map projections.

(iii) On which four (4) things is the selection of a map projection based?

[2 + 6 + 5 + 2 + 2 + 2 + 2 + 4] Marks

Question Five

Data visualisation is some form of visual communication that involves creation and ... its main goal is to communicate information

The University of Zambia
School of Engineering
Department of Geomatic Engineering
2015/6 ACADEMIC YEAR
MID-TERM TEST - JULY 2016

COURSE NAME: **PRINCIPLES OF DATA ACQUISITION AND PROCESSING**
COURSE CODE: GEE 3622
TIME: TWO (2) HOURS
TOTAL MARKS: 100
INSTRUCTIONS

1. **Answer: ALL THREE (3) QUESTIONS from SECTION A and ONE QUESTION from SECTION B**
2. This TEST is Closed Book
3. Calculators are permitted
4. Show all the work leading to the solution

SECTION A

1. a) Explain the following terms:

   i. **Depth of field of a lens**

   ii. **Illuminance of any photographic exposure**

   iii. **Panchromatic emulsion**

   iv. **Crab angle**

   v. **Y-Pallax**

b) A vertical aerial photograph was taken with a 152.4-mm-focal-length camera from a flying height of 1385 m above datum. Images *a* and *b* of two ground points A and B appear on the photograph, and their measured photo coordinates (corrected for shrinkage and distortions) are x_a=-52.35 mm, y_a=-48.27 mm, x_b=40.64 mm, and y_b=43.88 mm. Determine the horizontal length of line AB if the elevations of points A and B are 204 and 148 m above datum, respectively.

(2+2+2+2+2+15 marks)

Electromagnetic Radiation (EMR) is light energy detected when it comes into contact with an object (False. Ans EM)

The visible portion of the EM Spectrum ranges from 4 · m to 7 · m (False. Ans. 0.4 · m to 0.7 · m)

The most common bands of the EM spectrum used for remote sensing are cosmic, gamma and x-rays. (false. Ans. ultraviolet (UV), visible, infrared (IR) and microwave.

Remote sensing depends upon operation in wavelength regions of spectrum where spectral signatures occur for identification purposes. (true)

GROUP 2

$H_A = H - \frac{Bf}{p_a}$

The figure below shows an overlapping pair of truly vertical aerial photographs taken at equal flying height H above mean sea level (MSL) and having equal focal lenths f. The corresponding images of the ground point P are P_L on the left photo and P_R on the right photograph, respectively. The ground coordinate system XYZ has its origin at the MSL level location O of the left photo camera exposure station, i.e. the **X** and **Y** axes are parallel to the x and y axes of the photo system.

a) Derive the basic parallax equations for the ground coordinates of point P based on the illustrated geometry of the overlapping truly vertical photos.

b) Compute the ground coordinates $X_pY_pZ_p$ of point **P** using the previously derived parallax equations for the photo stereo pair, whose

focal length f=152mm, the air base B=1815m and the flying height H=3000m;

and the photo-coordinates of point **P** are:

for the left photo: x_L = +80.00mm y_L = -50.00mm, and

for the right photo: x_R = -20.00mm, y_R = -50.00

left − right

$p_a = x_a - x'_a$

$p_a = 100$

$H_A = H - \frac{Bf}{p_a}$

$X_p = B \frac{x_a}{p_a}$

$= 1815 \left(\frac{80.00}{100}\right)$

Question Two (10+4+5 marks)

a) Define the following terms:

- Collinearity
- Principal Point
- Nadir
- Isocenter

b) Briefly, state the main difference between a vertical photograph and a tilted photograph.

c) The distance between two points, measured on a vertical photograph, is 8.21 cm. The distance between these same two points, measured on a 1:5000 map, was found to be 1.43 cm. The average ground elevation between the two points is 300 m above mean sea level. Find the flying height at which the photograph was taken if the focal length used is 152.4 mm.

Question Three (15+10 marks)

a) Given the following 3x3 rotation matrices around the x-axis, y-axis and z-axis, respectively, derive the rotation matrix $R(\omega,\phi,\kappa)$ which converts the measured image coordinate system(camera coordinate system) x,y,-f to the camera system x'y'z' parallel to the reference system. Assume that ω,ϕ,κ are clockwise rotation angles around x,y,z, respectively.

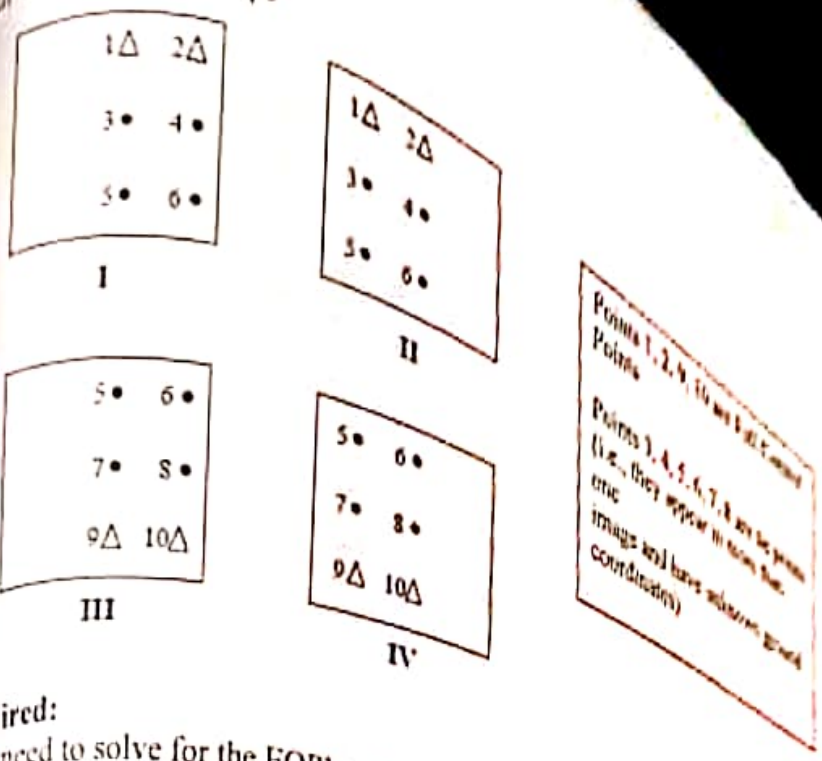
$$R(\omega) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\omega & \sin\omega \\ 0 & -\sin\omega & \cos\omega \end{pmatrix}, \quad R(\phi) = \begin{pmatrix} \cos\phi & 0 & -\sin\phi \\ 0 & 1 & 0 \\ \sin\phi & 0 & \cos\phi \end{pmatrix}, \quad R(\kappa) = \begin{pmatrix} \cos\kappa & \sin\kappa & 0 \\ -\sin\kappa & \cos\kappa & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Hint:

$$R(\omega,\phi,\kappa) = R(\kappa)R(\phi)R(\omega) = \begin{pmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{pmatrix}$$

b) Calculate the elements of the rotation matrix R, when ω= -0.0396 gon, ϕ=0.3070 gon and κ= -102.1708 gon.

Given:
Four images in two strips



Required:
If we need to solve for the EOP's of the four images and the ground coordinates of the points assuming known/errorless IOP's and ground coordinates of control points, analyze the observations-parameters and show the structure of each component of the Gauss-Markov model required to perform a least squares adjustment procedure:

$y = A\xi + e.$

Determine the following:

Observation-parameters analysis:
a) The observations

The measured image coordinates of points 1,2,3,4,5,6 on image I ? 6×2 = 12
The measured image coordinates of points 1,2,3,4,5,6 on image II ? 6×2 = 12
The measured image coordinates of points 5,6,7,8,9,10 on image III ? 6×2 = 12
The measured image coordinates of points 5,6,7,8,9,10 on image III? 6×2 = 12
Total n = 48

b) The parameters/unknowns

Known interior orientation parameters for the camera: xp, yp, c — 0 (errorless)
Exterior orientation parameters: Xo, Yo, Zo, ω, φ, κ for images I,II,III,IV — 4×6 = 24
The ground coordinates of the control points 1,2,9,10 — 0 (errorless)
The ground coordinates of the tie points 3,4,5,6,7,8 — 6×3 = 18
Total m = 42

n – m = 48 – 42 = 6

c) Redundancy

Due to this redundancy, the unknown parameters are determined through a least squares adjustment procedure.

(3+3+3+3+2+3+3+2+3) marks

The University of Zambia
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Department of Geomatic Engineering
2015/6 ACADEMIC YEAR
MID-TERM TEST - JULY 2016

COURSE NAME: PRINCIPLES OF DATA ACQUISITION AND PROCESSING
COURSE CODE: GEE 3622
TIME: TWO (2) HOURS
TOTAL MARKS: 100
INSTRUCTIONS

1. Answer: ALL THREE (3) QUESTIONS from SECTION A and ONE QUESTION from SECTION B
2. This TEST is Closed Book
3. Calculators are permitted
4. Show all the work leading to the solution

SECTION A

1. a) Explain the following terms:

   i. Depth of field of a lens

   ii. Illuminance of any photographic exposure

   iii. Panchromatic emulsion

   iv. Crab angle

   v. Y-Pallax

b) A vertical aerial photograph was taken with a 152.4-mm-focal-length camera from a flying height of 1385 m above datum. Images *a* and *b* of two ground points A and B appear on the photograph, and their measured photo coordinates (corrected for shrinkage and distortions) are x_a=-52.35 mm, y_a=-48.27 mm, x_b=40.64 mm, and y_b=43.88 mm. Determine the horizontal length of line AB if the elevations of points A and B are 204 and 148 m above datum, respectively.

(2+2+2+2+2+15 marks)

UNIVERSITY OF ZAMBIA

MID-SECOND SEMESTER TEST
MARCH 2012
GE 332
Photogrammetry I

Instructions:
Time: THREE (2) hours
Answer **ALL** questions from section A and **ONE** from section B

SECTION A

Question ONE(1)

a) Define briefly, the following photographic terms:
- Aperture - lens opening
- F-number - the ratio of the focal length to the diameter of the lens opening
- Illuminance - the amount of light received per unit area on an image plane surface during exposure
- Nadir point -
- Principle distance -
- Flying height - altitude of the camera
- Over lap - adjacent flight strips overlap

b) An aerial camera makes an exposure at a shutter speed of 1/1,000 sec. If the aircraft speed is 500 miles per hour, how far will the aircraft travel during the exposure?

c) What are the causes of radial lens distortion? List two of its characteristics. Use sketches to illustrate your answer
Radial lens distortion is caused from faulty grinding of the lens.
d) What are the relationships between?
- F-number and shutter speed
- Film speed and emulsion grain size
- Resolution and emulsion grain size

(6+7+6+6) marks

QUESTION 2

a) What is meant by exterior orientation? What parameters are involved?

b) What are the alternative methodologies for determining the exterior orientation parameters of an imaging system?

c) What is the difference between establishing the exterior orientation and the relative orientation for a stereo-pair?

d) What is the difference between relative and absolute orientation of a stereo pair? What parameters are involved in these orientation procedures?

e) Can you use relative orientation to reconstruct the real object space? Why?

f) Do we need ground control points to establish the relative orientation of a stereo-pair? Why?

g) Do we need ground control points to establish the absolute orientation of a photogrammetric model? Why?

(4+4+4+4+3+2+4 marks)

QUESTION 3

The image-to-ground coordinate relationship is established through the collinearity model and is represented by the collinearity equations:

$$x = x_p - c\frac{r_{11}\cdot(X-X_o)+r_{21}\cdot(Y-Y_o)+r_{31}\cdot(Z-Z_o)}{r_{13}\cdot(X-X_o)+r_{23}\cdot(Y-Y_o)+r_{33}\cdot(Z-Z_o)}$$

$$y = y_p - c\frac{r_{12}\cdot(X-X_o)+r_{22}\cdot(Y-Y_o)+r_{32}\cdot(Z-Z_o)}{r_{13}\cdot(X-X_o)+r_{23}\cdot(Y-Y_o)+r_{33}\cdot(Z-Z_o)}$$

The above equations involve the following quantities:

- The measured image point coordinates: x, y
- Interior orientation parameters of the camera: xp, yp, c
- Exterior orientation parameters of the image under consideration: $Xo, Yo, Zo, \omega, \varphi, \kappa$ where ω, φ, κ are embedded in the rotation matrix components:

r11 = cos φ cos κ	r12 = -cos φ sin κ	r13 = sin φ
r21 = cos ω sin κ + sin ω sin φ cos κ	r22 = cos ω cos κ - sin ω sin φ sin κ	r23 = -sin ω cos φ
r31 = sin ω sin κ - cos ω sin φ cos κ	r32 = sin ω cos κ + cos ω sin φ sin κ	r33 = cos ω cos φ

- The ground coordinates of point: X, Y, Z.

SECTION B

Question FOUR (4)

a) Discuss briefly,

i. The principle difference between a 'map' and a 'photo'

ii. Virtual and Real Image formation

b) What is meant by exterior orientation? What parameters are involved?

c) An aerial camera with IMC (Image Motion Compensation) is used to acquire photography at a flying height of 5200 m above ground. The focal length is 153.15 mm. The aircraft is flying at 325 km/hr and an exposure time of 1/250 second is used. How far across the focal plane must film travel during the exposure in order to obtain an image with no image motion blurring?

(10+8+7) marks

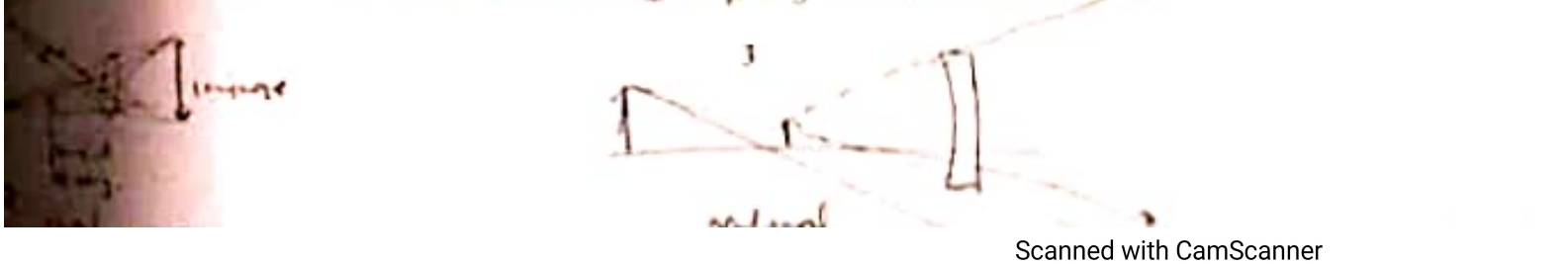
Question FIVE (5)

a) Describe the meaning of photosensitivity and spectral sensitivity of photographic material.

b) What is a diapositive and give one example?

c) Define the following photographic terms:

- Nodal points
- focal points
- focal length **Focal length is defined as the distance from the focal plane to the center of the lens when focused at infinity (figure 6.4).**



II. Engineering

III. Automotive, machines and shipbuilding industries

IV. Medicine and Physiology

V. Forensic including Police work

GROUP 5

a) In analytical photogrammetry, we often deal with matrix rotations in a plane for image points that must satisfy the orthogonality conditions. Given the following transformation:

$$\begin{pmatrix} X \\ Y \end{pmatrix} = \begin{pmatrix} 0.36 & 0.69 \\ 0.19 & 0.27 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

With the help of unit vectors

$$\mathrm{I} = \begin{pmatrix} \cos\alpha \\ \sin\alpha \end{pmatrix}, \qquad \mathrm{J} = \begin{pmatrix} -\sin\alpha \\ \cos\alpha \end{pmatrix}$$

State three (3) orthogonality conditions that must be satisfied for an orthogonal matrix and prove that the above transformation does not represent a rotation.

The figure below shows four models (1-4) which are observed

Independently

Question TWO (2)

a) What is meant by a vertical photograph? What is meant by a nearly vertical photography?

b) A vertical photograph captured at a flight height of 2000' above sea level shows a radio tower with a base elevation 540' above the same datum. The image of the tower has a relief displacement of 1.33". The distance from the photograph's principal point to the top of the tower is 5.97". What is the height of the tower?

c) Mention and explain one of the methods of camera calibration.

d) The line lies on fairly level terrain. Find the approximate flying height above terrain if the camera focal length = 90mm and the section line ab = 100mm (on photo) and on terrain AB = 1000m.

(7+5+8+5) marks

Question THREE (3)

(a) Discuss the darkroom procedure for black and white emulsion. Explain when and why a 'safe' light can be used in a darkroom

(b) Discuss the characteristic curve H and D, or D-log- E curve.

(c) Define the following terms:

- Filter
- Density
- Contrast
- Resolution

(d) Explain briefly,

- 'Depth of field'
- What are the effects of tilt and relief displacement on a photo?

(7+5+8+5) marks

Briefly, define the adjustment involved in these models?

The models are:

displaced (two translations, Xu,Yu)

rotated (rotation angle, k) and

scaled (scale factor,m)

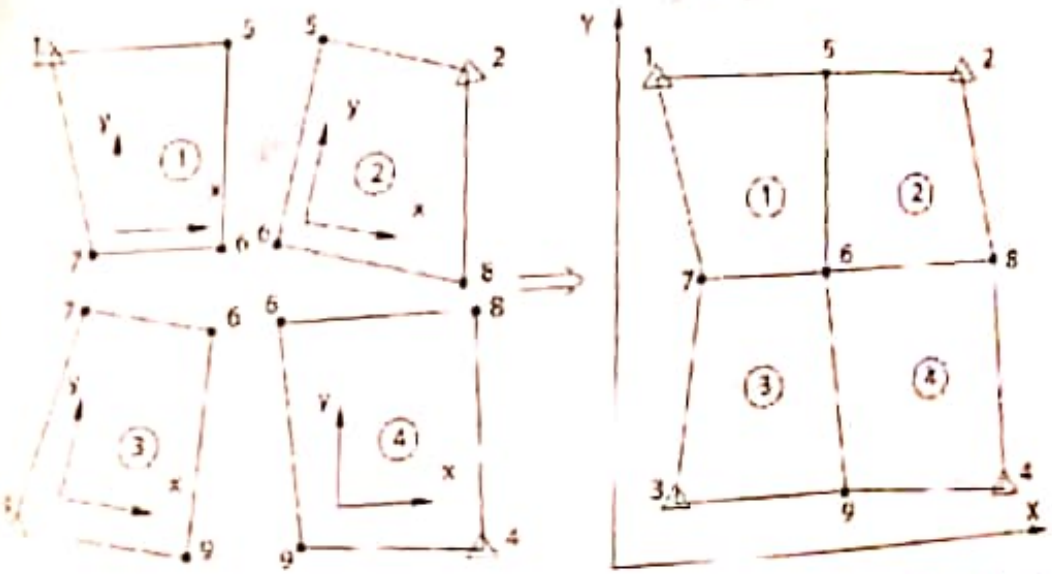
So that:

the tie points fit together as well as possible and

the residual discrepancies at the control points are as small as possible.

Why is the similarity (conformal) transformation used in the Block adjustment by independent models?

- The scale, position and orientation of the models may be changed but not its shape



SECTION A

Question 1

a) Provide the definition of space resection
i. How many and which are the unknown parameters for space resection
ii. What mathematical expression is used to determine the unknown parameters of the space resection
iii. What is required to be known to solve for the unknown parameters?

b) A project area is 16 km wide in east-west direction and 10.4 km long in north-south direction. It is to be covered with photos in scale 1:12000. The nominal end-lap and side-lap are to be 60% and 30%, respectively. A camera having a 152.4-mm focal length lens and a 230-mm square format is to be used.

Compute

i. Ground coverage
ii. The distance between two successive axes of the strips.
iii. Base in the strip
iv. Number of photos per strip (assuming two extra photos at each end of the strip to ensure coverage)
v. The intervalometer setting necessary to obtain the desired end-lap, assuming the aircraft flies at a velocity of 192km/h.

[13+10] marks

Question 2

a) Provide the definition of collinearity condition and give its mathematical expression. Explain the terms used in the mathematical expression

b) The figure below shows the angular field of view of a camera. Calculate the angular field of view for a nominal 152-mm focal-length camera with a 23cm square format. State whether this is a wide angle, normal angle or super-wide angle type of a single-lens frame camera.

Focal Plane

α=Angular field of View

Rear Nodal point of lens

$$\alpha = 2\tan^{-1}\left(\frac{d}{2f}\right)$$

UNIVERSITY OF ZAMBIA

SECOND SEMESTER EXAMINATIONS - MAY 2011

GE 332 - PHOTOGRAMMETRY I

Instructions:

Time: THREE (3) hours

Answer ALL questions from section A and ONE from section B

Chilombo Chipeta Sheen

SECTION A

QUESTION 1

(a) Define the following photographic terms:

- Aperture
- F-number
- Illuminance
- Front nodal and Rear Nodal Points of an aerial camera
- Isocenter
- Principle point
- Ground nodal point
- Swing and Tilt angle

(b) What are the relationships between?

- F-number and shutter speed
- Film speed and emulsion grain size
- Resolution and emulsion grain size

(c) What are the causes and characteristics of radial lens distortions? Use a representative sketch to explain two different types of radial lens distortion.

(8+9+8) marks

i) ...overlapping vertical photographs was taken from a flying height of 1,231 m above ... with a 154.4-mm-focal-length camera. The air base was 330 m. With the photos ... oriented, parallax bar readings of 12.57 mm and 13.04 mm were obtained with the ... mark set on the principle points O_1 and O_2, respectively. On the left photo b was ... as 93.73 mm and on the right photo b' was measured as 93.30 mm. Parallax bar ... of 10.96 mm and 15.27 mm were taken on points A and B. Also, the x and y photo ... of points A and B measured with respect to the flight axes on the left photo ... 53.41 mm, y_a = 50.84 mm, x_b=88.92mm, and y_b = -46.69 mm. Calculate the ... of points A and B and the horizontal length of line AB.

ii) ...the instrument usually employed to measure the position of a point in a photograph.

iii) ...at are the systematic errors contained in the measured photo-coordinates that disturb ... ideal linear relation between the perspective centre, the image point and the ground point?

(15+2+8) marks

SECTION B

Section 4

i Assuming the principle point to be at the intersection of lines joining opposite corner fiducial points, calculate the coordinates of those fiducial points in the conventional xy coordinate system if their comparator coordinates XY are as in the table below.

Fiducial points	X(mm)	Y(mm)
A	87.294	210.223
B	199.826	96.996
C	313.054	209.555
D	200.512	322.768

b) Define the following photogrammetric terms, give the number of the corresponding parameter elements required for their determination and name them.

i. Basic interior orientation

ii. Relative orientation

iii. Absolute orientation

iv. Exterior orientation

(13+12) marks

QUESTION 4

SECTION B

a) Define x-parallax and show with a figure how it [illegible] terrain

b) Derive parallax equations for any point A(x,y) [illegible] photos are taken from the same height above datum

c) The length of line AB and the elevation of its endpoints A and B, are to be determined from a stereopair containing images a and b. The [illegible] the photographs has a 152.4-mm lens. The flying height was 1200m. The measured photo coordinates of the two photos) and the airbase was 600m. The measured photo coordinates of points A and B in the "flight line" coordinate system are xa=54.61mm, xb=98.67mm,ya=50.80mm,yb= -25.40mm, x'a=-59.45, y'a=27.35mm, I and b length of line AB and elevation of A and B.

QUESTION 5

(5+10+10) marks

a) Discuss vertical, tilted and oblique type of photographs.

b) Briefly, distinguish between a map and a photo.

c) Assume a vertical photograph was taken at a flying height of 5000m above sea level using a camera with a 152-mm-focal-lenght lens. (a) Determine the photo scale at points A and B, which lie at elevations of 1200 and 1960 m. (b) What ground distance corresponds to a 20.1 mm photo distance measured at each of these elevations?

d) What is relief displacement? With the help of sketch diagrams, derive the formula for relief displacement.

e) Assume that the relief displacement for a tower appearing on a photo is 2.01mm, and the radial distance from the centre of the photo to the top of the tower is 56.43mm. If the flying height is 1220m above the base of the tower, find the height of the tower.

(5+5+5+5+5) marks

$$h = \frac{dH}{r}$$

$$d = \frac{rh}{H}$$

The nearer the object the greater the parallactic angle and vice versa. The depth between object A and B (DB-DA) is perceived as the difference in their parallactic angles (QA-QB)

a) Given that the shortest distance of clear stereoscopic depth perception for an average eye base of 65mm is 250mm, calculate the maximum Parallactic angle.

Stereoscopic Depth Perception

NB.

① Shortest distance of clear Stereoscopic depth perception for the average eye base of 65mm is 250mm

∴ Max parallactic angle will be

$$\Phi(max) = 2\tan^{-1}\frac{32.5mm}{250mm} \approx 15°$$

b) Given that the maximum distance at which the stereoscopic depth perception is possible is approximately 600m, calculate the minimum Parallactic angle.

$$= 2\tan^{-1}\frac{32.5}{600m}$$

$$= 0°0'22''$$

② Maximum distance at which the stereoscopic depth perception is possible is approx 600 m

$$\Phi(min) = 22''$$

List at least three examples of close range photogrammetry in each of the following applications

1. Information System – Image database, building facility management. project planning

Building information system

Question Two (14+4+7 marks)

a. Briefly, define the following photogrammetric terms.
- Pallaras
- Principal Point
- Illuminance
- Exposure Station
- Interior orientation parameters
- Exterior orientation parameters
- Fiducial Marks

b. Briefly, state the main difference between a map and a photograph.

c. State briefly, the relationships between?
- f-number and shutter speed
- Film speed and emulsion grain size
- Resolution and emulsion grain size

Question Three (20+5 marks)

a. Assuming the principle point to be at the intersection of lines joining opposite corner fiducial points, calculate the coordinates of those fiducial points in the conventional xy coordinate system if their comparator coordinates XY are as in the table below.

Fiducial points	X(mm)	Y(mm)
A	87.294	210.223
B	199.826	96.996
C	313.054	209.555
D	200.512	322.768

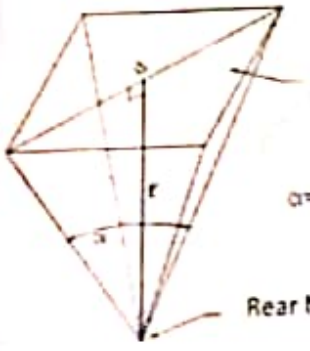
$(y_2 - y_1) = m(x_2 - x_1)$

$y = mx + c$

$y = mx + c$

$A = A' - O'$

b. The figure below shows the angular field of view of a camera. Calculate the angular field of view for a nominal 152-mm focal-length camera with a 23cm square format. State whether this is a wide angle, normal angle or super-wide angle type of a single-lens frame camera.



Question 5

a) Given the following 3x3 rotation matrix

$$R(\omega) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\omega & \sin\omega \\ 0 & -\sin\omega & \cos\omega \end{pmatrix}$$

$$R(\phi) = \begin{pmatrix} \cos\phi & 0 & -\sin\phi \\ 0 & 1 & 0 \\ \sin\phi & 0 & \cos\phi \end{pmatrix}$$

$$R(\kappa) = \begin{pmatrix} \cos\kappa & \sin\kappa & 0 \\ -\sin\kappa & \cos\kappa & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Derive the rotation matrix R (ω,φ,κ) that rotates the coordinate system of tilted photograph to the coordinate system parallel to the reference ground system.

Determine the rotation angles (ω,φ,κ) if R has the following form:

$$R = \begin{pmatrix} 0.999910 & 0.013319 & 0.001635 \\ -0.013351 & 0.999671 & 0.021907 \\ -0.001343 & -0.021927 & 0.999759 \end{pmatrix}$$

(Formulas: sin φ= r13, tan κ= -r12/r11, tan ω=-r23/r33)

b) Provide the definitions of the independent and the dependent methods of relative orientation. Name the projector elements used in each of them.

(15+10) marks

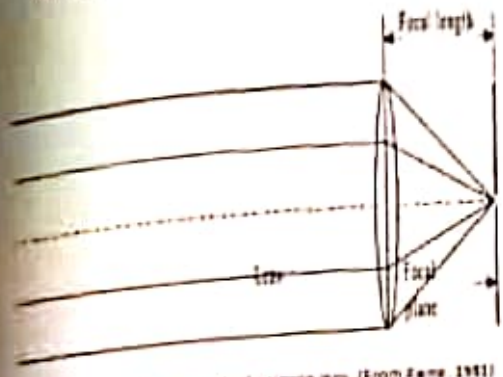


Figure 6.4. Focal length of a simple lens. (From Kemp, 1981)

d) The image distance for a photograph of an object, which is located 4.5 meters from the camera, is 76.5mm. What image distance is required for perfect focus if the object is in infinity?

(10+3+6+6) marks

SECTION B

...four (5+5+5+5+5 marks)

a) With the help of sketches, show how stereoscopic coverage is lost due to:

i) Tilt
ii) Unequal flying heights
iii) Terrain variations

b) Air base of a stereopair is 1400m and flying height above ground is 2400m. Camera has a 152.4 mm focal length and 23-cm format.

i) What is the percent *endlap*?
ii) Assuming spacing between adjacent lines is 2500m, what is the percent *side lap*?

...estion Five (3+18+4 marks)

In an *ideal* optical system, all rays of light from a point in the object plane would converge to the same point in the image plane, forming a clear image.

a) What term is used for the *influences* which cause different rays to converge to different points?

b) Mention and briefly explain **six (6)** types of the *influences* mentioned in (a). Support your answer with sketches of the aberration types.

c) Draw ray diagrams for a typical convex lens for a real and virtual image formation.

SECTION B

Question Four (15+10 marks)

a. With the help of sketches, show how stereoscopic coverage is lost due to
   i) Tilt
   ii) Unequal flying heights
   iii) Terrain variations

b. Air base of a stereopair is 1400m and flying height above ground is 2400m. Camera has a 152.4 mm focal length and 23-cm format
   i) What is the percent end lap?
   ii) Assuming spacing between adjacent lines is 2500m, what is the percent side lap?

c. An aerial camera with IMC (Image Motion Compensation) is used to acquire photography at a flying height of 5200 m above ground. The focal length is 153.15 mm. The aircraft is flying at 325 km/hr and an exposure time of 1/250 second is used How far across the focal plane must film travel during the exposure in order to obtain an image with no image motion blurring?

Question Five (4+6+15 marks)

a. What is relief displacement?

b. A vertical photo is taken from a height of 535 m above the datum. The elevation of the base of tower is 259m and the relief displacement'd' is measured as 54.1 mm. The radial distance to the top of the tower is 121.7 mm. What is the height of the tower?

c. The length of line AB and the elevation of its endpoints, A and B, are to be determined from a stereopair containing images a and b. The camera used to take the photographs has a 152.4-mm lens. The flying height was 1200 m (average for the two photos) and the air base was 600 m. The measured photographic coordinates of points A and B in the "flight line" coordinate system are x_a = 54.61 mm, x_b = 98.67 mm, y_a = 50.80 mm, y_b = -25.40 mm, x'_a = -59.45 mm, and x'_b = -27.39 mm. Find the length of line AB and the elevations of A and B.

REVISION QUESTIONS AUGUST 2017

GEE 3622-PRINCIPLES OF DATA ACQUISITION & PROCESSING

GROUP 1

Figure 1 of reflectance curves; show the spectral response patterns of deciduous and coniferous trees.

(a) Which range of the wavelength is the visible portion of the electromagnetic spectrum?

(b) Which range is the near-infrared (NIR) portion?

(c) Explain why it would be difficult to distinguish the two types of trees in the visible portion.

(d) Explain why it would easier to distinguish the two types of trees in the NIR portion.

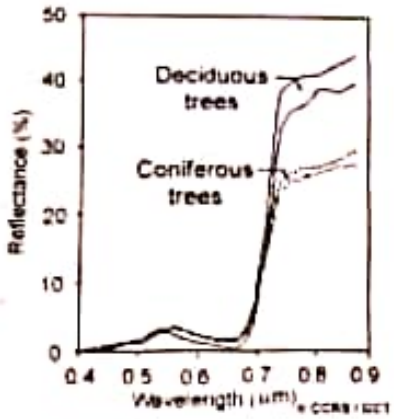


Figure 1: Reflectance curves for Deciduous trees and Coniferous trees

(a) Visible: 0.4 – 0.7 μm

(b) NIR: 0.7 – 0.9 μm

(c) The reflectance in the visible portion for both trees is low, and not clearly separable

(d) In the near-infrared, although both types reflect a significant portion of the incident radiation, they are clearly separable.